

supply lines of other of the plurality of modules. The control board of each module can optionally generate feedback data on a predetermined schedule.

**[0011]** A fluid pumping system for a tissue engineering system can include, but is not limited to including, a fluid handling set including a plurality of pneumatically-controlled fluid-pumping cassettes, a main controller, and a manifold including a plurality of pneumatic valve modules. The plurality of pneumatic valve modules can share a plurality of pressure buses. Each of the plurality of pneumatic valve modules can include a plurality of valves. Each of the plurality of valves can have an outlet in pneumatic communication with an associated cassette of the plurality of pneumatically-controlled fluid-pumping cassettes. Each of the plurality of valves can have at least one inlet in communication with a pressure bus of the plurality of pressure buses. Each of the pneumatic valve modules can include a control board configured to command actuation of the plurality of valves to selectively supply pressure to the associated cassette. The pressure can pump fluid through the fluid handling set. The control board can receive a main controller command from the main controller.

**[0012]** Each of the modules can optionally include a portion of each of the plurality of pressures buses. The plurality of pressure buses can be formed when at least one of the plurality pneumatic valve modules is coupled to at least another of the plurality of pneumatic valve modules. The fluid handling set can optionally include three pumping cassettes. A first cassette of the plurality of pneumatically-controlled fluid-pumping cassettes can optionally include a plurality of source ports, a plurality of outlet ports in communication with at least one storage reservoir, a second cassette of the plurality of pneumatically-controlled fluid-pumping cassettes including a plurality of inlet ports in communication with the at least one storage reservoir and a plurality of outlet ports in communication with a bioreactor, and a third cassette of the plurality of pneumatically-controlled fluid-pumping cassettes including a plurality of inlet ports in communication with the at least one storage reservoir and a plurality of outlet ports in communication with a bioreactor. The fluid pumping system can optionally include a communications bus enabling communications among the plurality of pneumatic valve modules formed as at least one of the plurality of pneumatic valve modules is coupled to at least another of the plurality of pneumatic valve modules.

**[0013]** A fluid pumping system can include, but is not limited to including, a pneumatically driven first pumping cassette and at least one pneumatically driven second cassette. The fluid pumping system can also include a storage reservoir, the storage reservoir being connected to the first pumping cassette by at least a first fluid line. The storage reservoir can be connected to the at least one second cassette by at least a second fluid line. The fluid pumping system can still further include a bioreactor configured to house a biological specimen. The bioreactor can be in fluid communication with each of the at least one second cassette. The fluid pumping system can also include a manifold. The manifold can include, but is not limited to including, a plurality of valve modules. The plurality of valve modules can be coupled together to form a plurality of pressure supply buses, a communication bus, and a power bus. Each of the valve modules can include a plurality of valves. Each of the valve modules can include a control board. The fluid pumping system can still further include a main controller

configured to generate a main controller command directed to the manifold. At least one of the control boards can be configured to receive the main controller command. At least one of the control boards can be configured to send module commands over the communications bus to recipient modules of the valve modules. The recipient modules can actuate, based on the module commands, the plurality of valves associated with the recipient module. The actuating can effect pumping of fluid by the first pumping cassette and the at least one second cassette.

**[0014]** The communications bus can optionally include a CANbus. The main controller can optionally be configured to generate and send a role command for each of the plurality of valve modules. Each of the role commands can optionally be sent to one of the recipient modules over the communications bus. The role command can optionally specify a valve configuration for each of the plurality of valves of the one of the recipient modules. The control board of the one of the recipient modules can optionally be configured to alter a valve setting for each of the plurality of valves associated with the one of the recipient modules based on the role command. The valve setting for each of the recipient module valves can optionally be a default setting. The default setting can optionally be modifiable by the role command. Each of the control boards can optionally be configured to generate valve state data. The control boards can optionally send the valve state data over the communications bus. The valve state data can optionally be generated each time a valve is actuated. Each of the control boards can optionally be configured to generate feedback data on a predetermined schedule. The control boards can optionally send the feedback data over the communications bus. The predetermined schedule can optionally be periodic, for example, but not limited to, every 100 ms. The feedback data can optionally include a pressure data signal generated by a pressure sensor. The pressure sensor can optionally be associated with the control board.

**[0015]** A system for engineering a tissue can include, but is not limited to including, at least one cassette having a flexible sheet covering at least one pumping chamber, the flexible sheet covering at least one cassette fluid valve. The system can also include a bioreactor housing the tissue. The bioreactor can be in fluid communication with the at least one cassette. The system can further include a controller and at least one module. Each at least one module can have at least one pressure bus and at least one valve, where the valve is in communication with the pressure bus. Each at least one module can have an outlet port associated with each or the valves. The outlet port can be in communication with the flexible sheet. The at least one module can include a first module having a first module processor. The first module processor can receive at least one controller command from the controller and can generate, based on the controller command, at least one second module command addressed to at least one second module. The at least one second module can have a second module processor that can receive the at least one second module command and can generate, based on the at least second module command, at least one valve command. The at least one valve command can govern fluid flow through the at least one valve of the at least one second module. The at least one valve can control pressure applied to the flexible sheet via the outlet ports. The tissue and the bioreactor can receive the fluid flow metered based